Claims

[c1]   1. A method for controlling on/off states of an engine in a hybrid electric vehicle powertrain, the method comprising the steps of:

generating a plurality of request state variables based on a comparison of vehicle operating conditions and requirements, each variable indicating an active or inactive status of a plurality of engine requests;

combining at least two request state variables to form a combined request state variable that contains active requests in the at least two request state variables;

simplifying the combined request state variable to eliminate any redundant requests and to resolve any conflicting requests;

providing a final request state variable; and

evaluating the final request state variable to determine whether a change in engine state is desirable.

[c2]   2. A method of controlling the on/off state of an engine in a hybrid electric vehicle powertrain comprising the following steps:

generating a plurality of request state variables based on a comparison of vehicle operating conditions and re-

quirements, each variable indicating the active or inactive status of each of a plurality of engine requests, the value of each request state variable being constrained to a set of fundamental request states;

combining at least two request state variables to form a combined request state variable that contains active requests in the at least two request state variables;

simplifying the combined request state variable to eliminate any redundant requests and to resolve any conflicting requests;

providing a final request state variable; and

evaluating the final request state variable to determine whether a change in engine state is desirable.

[c3]   3. The method of Claim 2 wherein the step of combining joins two or more request states through a bitwise OR operation.

[c4]   4. The method of Claim 3 wherein the step of simplifying includes an arbitration operation that follows the requests according to a predetermined priority.

[c5]   5. The method of Claim 2 wherein said engine requests are grouped in hierarchical levels through the combining and simplifying steps.

[c6]   6. The method defined in Claim 2 wherein the step of

evaluating the final request state variable includes the step of:

transitioning a state machine from an engine off state to an engine on state in accordance with the following expression:

$$\left(\overline{fpu} + pu \bullet \overline{ipu} \right) \bullet \overline{fpd} \, ,$$

where fpu, pu, ipu and fpd are engine request variables identifying the active or inactive status of engine requests.

[c7]   7. The method of Claim 2 wherein each fundamental request state comprises a 6 bit binary word, each bit identifying whether an engine request state is active or inactive.

[c8]   8. The method defined in Claim 2 wherein the step of evaluating the final request state variable includes the step of:

transitioning a state machine from an engine on state to an engine off state in accordance with the following expression:

$$fpd + pd \bullet \overline{fpu} \bullet \overline{ipd} \bullet \overline{pu}$$,

where fpd, pd, fpu, ipd, and pu are engine request variables identifying the active or inactive status of engine requests.

[c9] 9. The method defined in Claim 2 wherein the step of evaluating the final request state variable includes the steps of:

transitioning a state machine from an engine on state to an engine off state in accordance with the following expression:

$$fpd + pd \bullet \overline{fpu} \bullet \overline{ipd} \bullet \overline{pu}$$

and otherwise maintaining the state machine in an engine on state; and

transitioning said state machine from an engine off state to an engine on state in accordance with the following expression:

$$\left(fpu + pu \bullet \overline{ipu}\right) \bullet \overline{fpd}$$

and otherwise maintaining the state machine in an engine off state;

where fpd, pd, fpu, ipd, pu, and ipu are engine request variables identifying the active or inactive status of engine requests.

[c10]   10. The method of Claim 8 wherein each fundamental request state comprises a 6 bit binary word, each bit identifying whether an engine request state is active or inactive.

[c11]   11. The method of Claim 9 wherein the step of combining joins two or more request states through a bitwise OR operation.

[c12]   12. The method of Claim 10 wherein the step of simplifying includes an arbitration operation that follows the requests according to a predetermined priority.

[c13]   13. The method of Claim 11 wherein the engine requests are grouped in hierarchical levels through the combination and simplification steps.

[c14]   14. A system for controlling on/off states of an engine in

a hybrid electric vehicle powertrain comprising:

means for generating a plurality of request state variables based on conditions and requirements, each variable indicating the active or inactive states of each of a plurality of engine requests;

means for combining at least two request state variables to form a combined request state variable that contains active requests in the at least two request state variables;

means for simplifying the combined request state variable to eliminate redundant requests and to resolve any conflicting requests;

providing a final request state variable; and

means for evaluating the final request state variable to determine whether a change in engine state is desirable.

[c15]   15. A system for controlling the on/off state of an engine in a hybrid electric vehicle powertrain comprising:

means for generating a plurality of request state variables based on a comparison of vehicle operating conditions and requirements, each variable indicating the active or inactive status of each of a plurality of engine requests, the value of each request state variable being constrained to a set of fundamental request states;

means for combining at least two request state variables to form a combined request state variable that contains active requests in the at least two request state variables;

means for simplifying the combined request state variable to eliminate any redundant requests and to resolve any conflicting requests;

providing a final request state variable; and

means for evaluating the final request state variable to determine whether a change in engine state is desirable.

[c16]   16. The system of Claim 14 wherein each request state variable contains a plurality of bits, the means for combining joins two or more request states including a bitwise OR operation.

[c17]   17. The system of Claim 15 wherein the means for simplifying includes an arbitration operation that follows the requests according to a predetermined priority.

[c18]   18. The system of Claim 14 wherein said engine requests are grouped in hierarchical levels through the combining means and simplifying means.